What is the relationship between glycemic index or glycemic load and type 2 diabetes?

Conclusion

A moderate body of inconsistent evidence supports a relationship between high glycemic index and type 2 diabetes.

Strong, convincing evidence shows little association between glycemic load and type 2 diabetes.

Grade: GI: Moderate; GL: Strong

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Evidence Summary Overview

Evidence is mixed as to whether there is an association between a high glycemic index and type 2 diabetes (T2D). Little evidence suggests that a high glycemic load is associated with T2D. This conclusion is based on 10 longitudinal prospective observational studies published since 2000 (Barclay, 2007; Halton, 2008; Hodge, 2004; Krishnan, 2007; Mosdol, 2007; Sahyoun, 2008; Schulz, 2006; Schulze, 2004; Stevens, 2002; Villegas, 2007). No randomized controlled trials (RCTs) were reported. Of the 10 prospective observational studies, glycemic index was positively associated with T2D in five reports (Halton, 2008; Krishnan, 2007; Schulz, 2006; Schultze, 2006; Villegas, 2007). Four other longitudinal studies reported no association of glycemic index with T2D (Barclay 2007; Mosdol 2007; Sahyoun 2008; Steven 2002). One longitudinal study reported an inverse association (Hodge, 2004).

Of the 10 prospective observational studies, one study reported a significant, positive association between glycemic load and risk of T2D during 20 years of follow-up in comparison of extreme deciles (Halton, 2008). Six studies found no relationship (Barclay, 2007; Hodge, 2004; Krishnan, 2007; Sahyoun, 2008; Schulz, 2006; Stevens, 2002). Two studies found an inverse association (Mosdol, 2007; Villegas, 2007).

Evidence Summary Paragraphs

Barclay, 2007 (neutral quality), a prospective cohort study, examined the link between glycemic index (GI) and fiber and incidence of T2D in an older Australian population. The study began in 1991 and 4,433 subjects aged more than 49 years were identified. Of these, 3,654 participated in a detailed examination in 1992 to 1994; 2,335 participated in a five-year follow-up; and 1,952 participated in a 10-year follow-up. Subjects were Caucasian and representative of the older Australian population. Diagnosis of T2D was either self-reported with current use of diabetes medication or fasting glucose concentration of more than 126mg per dL. Diabetes incidence was measured based on subjects without T2D at baseline who were diagnosed with T2D at subsequent follow-up stages. Glycemic index was evaluated based on a 145-item semi-quantitative, Willett-derived, food-frequency questionnaire (FFQ) that was validated by these authors for ranking subjects accurately according to GI [Barclay et al, 2007 (Public Health Nutrition)]. It should be noted, however, that in validating the FFQ, the authors found the FFQ could rank subjects according to total carbohydrate, sugar, starch and fiber intake and GI, but not as well for glycemic load (GL). During ten years of follow-up, 138 cases of T2D were identified out of the 1,833 subjects. Total carbohydrate, starch, sugar and total fiber intake were not correlated with T2D incidence in age- and sex-adjusted models or the multivariate-adjusted model. However, vegetable fiber had a negative association with risk of T2D in the age- and sex-adjusted and multivariate analysis models. For all ages combined, there was a trend toward a positive correlation between GI and T2D risk, although this was not statistically significant. However, in the age-stratified and multivariate analyses, there was a positive correlation between GI and T2D risk for individuals less than 70 years at baseline, but not those older than 70 years at baseline. Overall, the authors concluded that vegetable fiber was independently associated with decreased incidence of T2D over a 10-year period in older Australians; whereas, in a secondary analysis, there was a positive association between GI and T2D incidence in older Australian subjects less than 70 years at baseline. Limitations of this study include the FFQ that these authors reported previously was not well-suited for grouping subjects by GL.

Halton, 2008 (positive quality), a prospective cohort study (Nurses' Health Study) in the US, examined the association between low-carbohydrate-diet score and risk of T2D. In addition, the relationship between dietary glycemic load and risk of T2D was examined. Participants were 85,059 women (98% white) aged 30 to 55 years at baseline. Participants were followed from 1980 to 2000. Diet was assessed using FFQs and T2D status was self-reported. During 20 years of follow-up, 4,670 cases of T2D were documented. There was a significant, positive association between glycemic load and risk of T2D in comparison of extreme deciles (multivariate RR: 2.47; 95% CI: 1.75, 3.47; $P<0.0001$).

Hodge, 2004 (positive quality), a prospective cohort study, examined the association between glycemic index (GI), glycemic load (GL) and T2D. Participants were 31,641 men and women (40 to 69 years old at baseline) from the Melbourne Collaborative Cohort Study. Participants completed baseline questionnaires between 1990 and 1994. Dietary information was collected using a 121-item, self-administered FFQ developed for the cohort study. Incident cases of diabetes were self-reported on a questionnaire mailed to participants four years after baseline. Confirmation of diagnosis was sought from medical practitioners. A total of 365 cases of T2D were reported (76% of cases confirmed). Dietary GI was positively associated with diabetes. When body mass index (BMI) and waist to hip ratio (WHR) were included in the model, the association was attenuated. In participants with BMI less than 25kg/m^2, GI was inversely associated with diabetes (OR=0.29; 95% CI: 0.10, 0.91). In people with BMI less than 30kg/m^2, GI was not associated with diabetes (1.00; 95% CI: 0.68, 1.46), whereas in those with BMI 30kg/m^2 or more, a positive association (1.64; 95% CI: 1.22, 2.21) was observed (interaction, P=0.01). Glycemic load showed little association with diabetes. The authors concluded that reducing GI while maintaining carbohydrate intake may reduce the risk of T2D.

Krishnan, 2007 (positive quality), a prospective cohort study, examined the association of glycemic index (GI), glycemic load (GL) and cereal fiber intake and risk of T2D in a cohort of black women. Data from the Black Women's Health Study (BWHS), a prospective cohort study of 59,000 black women in the US, was used for this analysis. After exclusion criteria were applied, 40,078 women remained in the study. The study began in 1995 when women between the ages of 30 to 69 years were recruited by postal questionnaires, resulting in the recruitment of women from all regions of the US. This report was based on a follow-up from 1995 to 2003. Diet was assessed at baseline in 1995 with a 68-item modified version of the Block National Cancer Institute (NCI) FFQ that had been modified to include foods unique to the black population. The Cox proportional hazards models were used to calculate the incidence rate ratios (IRR) and 95% confidence intervals (CI). During the 123,499 person-years follow-up, there were 1,938 cases of T2D reported. Glycemic load was inversely associated with risk of T2D in the age-adjusted model; however, after adjustment for

BMI, energy intake, family history of T2D, smoking and physical activity (Model 1), the inverse association was lost. Further adjustment for fiber intake, total fat intake and total protein intake (Model 2) resulted in an IRR of 1.22 (95% CI: 0.98, 1.51), comparing the highest to the lowest quintile. Glycemic index was positively associated with T2D risk for all models; for Model 2, the IRR was 1.23 (95% CI: 1.05, 1.44) for the highest to lowest quintiles of GI. Lastly, cereal fiber intake was inversely associated with T2D risk in all models; the IRR was 0.82 (95% CI: 0.70, 0.96). Overall, both GI and GL were positively associated with increased risk of T2D and cereal fiber intake was negatively associated. These associations were valid in both overweight and non-overweight individuals, but stronger in thinner women. For women with a BMI less than 25kg/m^2, there was an approximate two-fold increase in risk of T2D for the highest quintile of GI and a 59% decrease for the highest quintile for fiber intake. The authors concluded that risk of T2D was statistically significantly associated with GI, but not with GL. Furthermore, their recommendations only address fiber (i.e., increasing cereal fiber in the diet may be protective against T2D, a disease that is of high incidence in this population of black women). Potential problems with this study were the difficulty in assessing GL (e.g., as cereal fiber intake increases, GL also increases). Furthermore, in the study population, those in the higher quintiles for GL also were more health conscious as indicated by lower cigarette and alcohol consumption, more physical activity, lower BMI and lower fat intake and, according to the authors, this may explain the initial positive association between GL and T2D incidence. However, when the above confounders were taken into account in their model, the direction of the association changed. The authors also warn that when their data was stratified according to BMI and they found that women with BMI less than 25kg/m^2 had a stronger association between GL and cereal fiber and T2D risk, that the stratification according to less than 25 and higher than 25kg/m^2 may have produced this outcome "by chance." They make a point that their results should not be interpreted to mean that overweight and obese women should not reduce their intake of refined carbohydrates for prevention of T2D.

Mosdol, 2007 (neutral quality), a prospective cohort study (Whitehall II Study) in the United Kingdom, examined the associations between glycemic index and glycemic load with clinical variables at baseline and incidence of T2D. Participants were 7,321 white adults (71% men) aged 39 to 63 years at baseline. Participants were followed for seven phases from 1995 to 1998 (phase 1) through 2003 to 2004 (phase 7). Diet was assessed using an FFQ for Western diets. Type 2 diabetes was self-reported throughout the study. In addition, two-hour glucose tolerance tests were conducted at clinical exams during phases three, five and seven (five-year intervals). During 13 years of follow-up, 329 incident cases of T2D were identified. Glycemic index was not associated with risk even after further adjustments for employment grade (measure of SES), physical activity, smoking status, alcohol intake, fiber intake and carbohydrate intake; and WHR and BMI. Hazard ratios across tertiles of glycemic load showed a significant, inverse association with T2D risk in the base model. Sex-specific tertiles of glycemic load were 1.00, 0.92 (95% CI: 0.71, 1.19), and 0.70 (95% CI: 0.54, 0.92) (adjusted for sex, age, and energy-misreporting; P=0.01). The association remained after adjustment for employment grade, physical activity, smoking and alcohol, but it was NS after further adjustment for carbohydrate and fiber intakes or in a model additionally adjusted for WHR and BMI. Higher glycemic index and glycemic load were not associated with increased risk of incident diabetes. Higher glycemic load was associated with a decreased risk of T2D in some models.

Sayhoun, 2008 (positive quality), a prospective cohort study drawn from the Health, Aging, and Body Composition (Health ABC) Study, consisted of a random sample of Medicare-eligible individuals (aged 70 to 79) from Pittsburgh PA and Memphis TN. Participants (N=1,898; women, N=1,027; men, N=871) were eligible for the study if they remained in the same area for more than three years and had no life-threatening cancers and could conduct basic daily activities unassisted. The relevance of studying an elderly population is that the incidence of T2D has doubled over the last 20 years, and people more than 60 years account for approximately half of this increase. The results in this report were drawn from the first six years of the Health ABC Study. Dietary intake was measured in the second year of the Health ABC study using a FFQ based on the Block questionnaire (Block Dietary Data Systems, Berkeley, CA), which included age-appropriate foods. A computer SAS program was developed to calculate GI and GL of the foods eaten by participants in the study. Diagnosis of T2D was based on: 1) Physician's report, 2) Use of insulin or hypoglycemic medications, and 3) Blood glucose levels higher than 126 mg per dL measured in years two, four and six. Subjects were grouped based on quintiles of GI and GL. Multivariate logistic regression was used to determine risk of T2D by quintile of energy adjusted dietary GI and GL. The data showed that neither dietary GI nor GL were significantly associated with risk of developing T2D, either before or after controlling for age, sex, race, clinical site, education, physical activity, baseline fasting glucose, BMI, alcohol consumption and smoking. For GI, the means of Q2 to Q5 were not significantly different from Q1 [OR (95% CI), P=0.7152 and P=0.8628, for unadjusted and adjusted, respectively]. For GL the means of Q2 to Q5 were NS different from Q1 [OR (95% CI), P=0.1234 and P=0.1147, for unadjusted and adjusted, respectively]. This study also showed that dietary GI and GL were negatively correlated with total fat, saturated fat and alcohol consumption; both GI and GL were positively correlated with carbohydrate and GL was positively associated with fruit and fiber intake. Notably, low dietary GI and GL patterns were not necessarily compatible with current dietary guidelines. Limitations of the study involved limitations of the GI and GL indices themselves, in that these indices may not provide enough information on the overall composition of the diet, type of carbohydrate in the diet, and dietary risk of T2D. Another specific limitation of this study was that, due to a cohort of similar age and functional status, there was a relative narrow range of GI and GL status and the quintile means fell within a narrow range (approximately 50 to 60). The authors concluded that the homogeneity of the study population may have diminished the associations between dietary GI and GL and risk of developing T2D.

Schulz, 2006 (neutral quality), a prospective cohort study, evaluated the impact of GI and GL on risk of T2D in the multiethnic Insulin Resistance Atherosclerosis Study (IRAS), focusing on the relationship between GI and GL on abdominal obesity and waist circumference (WC) measurements. In a previous study, this group showed that abdominal adiposity was associated with decreased insulin sensitivity in this same population. Subjects (1,600) for the study were recruited from four clinical centers between 1992 to 1994, with equal representation across gender, age (40 to 49, 50 to 59, 60 to 69 years), ethnicity (African American, Hispanic and non-Hispanic white) and glucose tolerance ranges (normal, IGT, and T2D). This cohort was followed up after five years. Dietary intake was assessed using a one-year, semi-quantitative, 114-item food frequency interview. This study included 892 subjects who were free from T2D at baseline and who returned for follow-up examination. At five-year follow-up, subjects diagnosed with T2D according to the World Health Organization (WHO) criteria were considered for the incidence of T2D in this cohort: 146 cases of T2D were identified. Multiple logistic regression analysis was used to assess the relationship between GI and GL and T2D risk. The average GI and GL for diabetic subjects was 59.5 and 127.9, respectively, NS different from non-diabetic subjects, 58.6 and 121.8, respectively. In multivariate regression models, GI and GL were not associated with increased risk of T2D. Stratification by abdominal obesity status at baseline showed a positive association between GI and T2D risk among non-abdominally obese subjects, whereas, there was no association in subjects with abdominal obesity. Interestingly, stratification by five-year waist change showed a positive association between GI and T2D risk in subjects who experienced an increase in waist circumference. This association was strongest among subjects without abdominal obesity at baseline: a one-unit increase in GI increased T2D risk by 12% (OR=1.12; 95% CI: 1.03, 1.21) in subjects with waist increase without abdominal obesity at baseline. No significant association was found between GL and T2D risk with stratification by either abdominal obesity or waist change. The authors conclude that an increase in dietary GI increases the risk of T2D in non-abdominally obese subjects and subjects with increased WC. Furthermore, this association is stronger in subjects who were both non-abdominally obese at baseline and showed WC increase over the duration of the study. A major limitation of this study was the IRAS subject population which, due to sampling design, has a one-third incidence of impaired glucose tolerance (IGT) and a cohort that is much more overweight (mean BMI=28.4kg/m^2) than an average American cohort.

Schulze, 2004 (positive-quality) examined the association of GI, GL and dietary fiber on T2D risk in young women from the Nurses' Health Study II, a prospective cohort study of 116,671 nurses in the US who were 24 to 44 years at baseline. This cohort was followed up with biennial mailed questionnaires on lifestyle factors and health outcomes. After exclusion, 91,249 women were included for the analysis. In 1991, these 91,249 women completed a semi-quantitative FFQ and were followed for eight years for T2D incidence. A similar FFQ was used 1995 to update dietary intake data. The Cox proportional hazards analysis method, stratified on five-year age categories, was used to estimate relative risks (RR) for each category of intake (quintiles). During the 716,300 person-years follow-up, 741 T2D cases were diagnosed. Increasing GI was strongly associated with a progressively higher risk of T2D; the RR from the age-adjusted quintiles, highest to lowest GI, was 1.79 (95% CI: 1.43, 2.25). This association remained high after further adjustments for BMI, alcohol consumption, smoking, family T2D history and numerous other covariates including different dietary and fat intakes. On the other hand, in age-adjusted analysis, both GL and total carbohydrate intake were inversely correlated with T2D risk; however, this significant association disappeared after adjustment for BMI and the other covariates listed above. There was a significant inverse association between total dietary fiber intake and T2D risk; the RR from the age-adjusted quintiles, highest to lowest GI, was 0.53 (95% CI: 0.42, 0.67), with cereal fiber having the strongest association with decreased T2D risk; the RR from the age-adjusted quintiles, highest to lowest GI, was 0.32 (95% CI: 0.25, 0.45). However, the inverse association between total fiber intake and T2D risk was attenuated by further adjustment with the above covariates beyond adjustment for age and BMI; whereas the inverse association between cereal fiber intake and T2D risk was maintained. Lastly, the data were also stratified to assess whether the associations with GI, GL and total carbohydrate intake were modified by BMI, physical activity and family T2D history. No major changes were observed for BMI. For physical activity, women in the lower two quintiles of activity scores had RRs of 2.01 for GI (highest to lowest quintile comparison) (95% CI: 1.38, 2.93) and 1.65 for GL (95% CI: 1.01, 2.70). Among women with no family history of T2D, the RR for GL and T2D was 1.02 (95% CI: 0.64, 1.63), but among women with a family history of T2D, the RR was 2.04 (95% CI: 1.13, 3.66).

Stevens, 2002 (positive quality), a prospective cohort study (Atherosclerosis Risk in Communities [ARIC] Study) in the US, examined the association of dietary fiber and glycemic index with T2D in African American and white adults. Participants were 12,251 adults (9,529 white, 2,722 African American) aged 45 to 64 years at baseline. The cohort study was initiated in 1987 to 1989 and included a maximum of four clinical trials that took place at approximately three-year intervals. Diet was assessed with an interviewer administered FFQ and T2D status was determined by fasting blood glucose (FBG), non-fasting glucose level, self-report or use of diabetes medication. During nine years of follow-up, 1,447 cases of diabetes were reported. After adjustment for age, BMI, education, smoking status, physical activity, sex and field center, there was NS association of glycemic index or glycemic load with incident diabetes. The HR for extreme quintiles of GL was 1.10 (95% CI: 0.90, 1.39) in white adults and 0.97 (95% CI: 0.73, 1.35) in African American adults in the fully adjusted model.

Villegas, 2007 (positive quality) was a five-year prospective cohort study of 64,227 middle-aged Chinese women with no history of diabetes or other adult degenerative disease. Food-frequency questionnaires were used for in-person interviews conducted on dietary intake and physical activity. These were conducted at baseline and at the first follow-up interview. The FFQ was designed for, and validated in, this population in Shanghai (Shanghai Women's Health Study FFQ). A total of 1,608 were diagnosed with T2D, as recorded in follow-up interviews using criteria of the American Diabetes Association (ADA). Associations between total carbohydrate intake, glycemic index (GI), glycemic load (GL) and specific food groups and T2D incidence were evaluated using multivariable Cox proportional hazards models. Findings showed that high carbohydrate intake and rice consumption were positively associated with T2D incidence. Comparing the highest vs. the lowest quintiles of intake, the multivariable-adjusted estimates of risk were 1.28 (95% CI: 1.09, 1.50) and 1.78 (95% CI: 1.48, 2.15) for carbohydrate and rice consumption, respectively. The percentage of energy from carbohydrates was also associated with increased risk of T2D; estimated risk of 1.37 in highest to lowest quintile comparison (95% CI: 1.11, 1.69), as was GI [estimated risk of 1.21 in highest to lowest quintile comparison (95% CI: 1.03, 1.43)] and GL [estimated risk of 1.34 in highest to lowest quintile comparison (95% CI: 1.13, 1.58)]. Overall, the intake of rice was associated with the greatest increase risk of T2D.

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Author, Year, Study Design, Class, Rating	**Population/Subjects**	**Methodology**	**Significant Outcomes**
Barclay AW, Flood VM et al, 2007 Study Design: Prospective Cohort Study Class: B Rating:	N=1,833 total. Study begun in 1991, subjects were 49 years at the start. Subjects were mostly caucasian, representative of older Australian population.	Diabetes incidence measured based on subjects without T2D at baseline who were diagnosed with T2D at subsequent follow-up in 1992 to 1994, five years and 10 years.	During ten years follow-up, 138 cases of T2D identified out of 1,833 subjects. Total CHO, starch, sugar and total fiber intake were not correlated with T2D incidence in age-and sex-adjusted models or the multivariate-adjusted model. Vegetable fiber had significant negative association with risk of T2D in the age- and sex-adjusted models: HR=0.72 (95% CI: 0.57, 0.93) P=0.010; <70 years at baseline [HR=0.72 (95% CI: 0.54, 0.96) P=0.027]. In multivariate model: HR=0.76 (95% CI: 0.57,

			0.99) P=0.048. NS when stratified by age with multivariate analysis adjustment. In age-stratified and multivariate analyses, there was a positive correlation between GI and T2D incidence for individuals <70 years, but not those >70 years at baseline [HR=1.75 (95% CI: 1.05, 2.92) P=0.031].
Halton TL, Liu S et al, 2008 Study Design: Prospective cohort Class: B Rating: ⊕	N=85,059 women. Nurses' Health Study. Age: 30 to 55 years at baseline. 98% white. Location: United States.	Followed from 1980 to 2000. Diet assessed with FFQ in 1980, 1984, 1986, 1990, 1994 and 1998. T2D self-reported (with follow-up by additional questionnaire).	During 20 years of follow-up 4,670 cases of T2D were reported. Significant positive association between glycemic load and risk of T2D in comparison of extreme deciles (multivariate RR: 2.47; 95% CI: 1.75, 3.47; P<0.0001).
Hodge AM, English DR et al, 2004 Study Design: Prospective Cohort Study Class: B Rating: ⊕	N=31,641 men and women from the Melbourne Collaborative Cohort Study. Age: 40 to 69 years at baseline.	Participants completed baseline questionnaires (including FFQ) between 1990 and 1994. Incident cases of diabetes were self-reported on a questionnaire mailed to participants four years after baseline. Confirmation of diagnosis was sought from medical practitioners. Dietary information was collected using a 121-item, self-administered FFQ developed for the cohort study.	365 cases of T2D were reported (76% of cases confirmed). Dietary GI was positively associated with diabetes. When BMI and WHR were included in the model, the association was attenuated. In participants with BMI <25kg/m^2, GI was inversely associated with diabetes (OR=0.29, 95% CI: 0.10, 0.91). In people with BMI <30kg/m^2, GI was not

			associated with diabetes (1.00, 95% CI: 0.68, 1.46), whereas in those with BMI of ≥30kg/m^2, a positive association (1.64, 95% CI: 1.22, 2.21) was observed (interaction, P=0.01). GL showed little association with diabetes.
Krishnan S, Rosenberg L et al, 2007 Study Design: Prospective Cohort Study Class: B Rating:	N=40,078 women from BWHS. Study began in 1995. Women ages 30 to 69 years recruited by mail from all regions of US.	Examined association of GI, GL and cereal fiber intake and risk of T2D in cohort of women from BWHS. Follow-up 1995 to 2003. Diet assessed at baseline with 68-item modified Block National Cancer Institute (NCI) FFQ modified to include foods unique to black population. Cox proportional hazards models were used to calculate incidence rate ratios (IRR) and 95% CI.	For 123,499 person-years follow-up: 1,938 T2D cases. GL inversely associated with risk of T2D in age-adjusted model; after adjustment for BMI, energy intake, family history of T2D, smoking and physical activity (Model 1), inverse association lost. Further adjustment of GL for fiber intake, total fat intake and total protein intake (Model 2) resulted in an IRR of 1.22 (95% CI: 0.98, 1.51), comparing highest to lowest GL quintiles. GI positively associated with T2D risk for all models; for Model 2, the IRR was 1.23 (95% CI: 1.05, 1.44) for the highest to lowest GI quintiles. Cereal fiber inversely associated with T2D risk in all models; the IRR was 0.82 (95% CI: 0.70, 0.96).
Mosdol et al 2007 Study Design: Prospective cohort	N=7,321 white adults (71% men). Whitehall II Study. Age: 39 to 63 years at	Participants followed for seven phases from 1995 to 1998 (phase one) through 2003 to 2004 (phase seven). Diet assessed with FFQ for	During 13 years of follow-up, 329 incident cases of T2D were identified. GI not associated with risk even after further

Class: B Rating:	baseline. Location: United Kingdom.	Western diets. T2D self-reported throughout study and two-hour GTT conducted at clinical exams during phases three, five and seven (five-year intervals).	adjustments for employment grade (measure of SES), physical activity, smoking status, alcohol intake, fiber intake and CHO intake; and WHR and BMI. HRs across tertiles of glycemic load showed a significant, inverse association with T2D risk in base model. Sex-specific tertiles of glycemic load were 1.00, 0.92 (95% CI: 0.71, 1.19) and 0.70 (95% CI: 0.54, 0.92) (adjusted for sex, age and energy-misreporting; P=0.01). The association remained after adjustment for employment grade, physical activity, smoking and alcohol, but it was NS after further adjustment for CHO and fiber intakes or in a model additionally adjusted for WHR and BMI.
Sahyoun N, Anderson A et al, 2008 Study Design: Prospective Cohort Study Class: B Rating:	N=1,890 total (1,027 women; 871 men). Age: 70 to 79 years. Recruited for the Health ABC Study of elderly Americans from Pittsburgh, PA and Memphis, TN.	Study from first six years of Health ABC Study. Dietary intake was measured in second year of Health ABC study using a FFQ based on the Block questionnaire with age-appropriate foods. Health information was collected at two, four and six years. Subjects were grouped based on quintiles of GI and GL.	Neither dietary GI nor GL were significantly associated with risk of developing T2D. GI: Means of Q2 to Q5 were NS different from Q1 [OR (95% CI), P=0.7152 and P=0.8628, for unadjusted and adjusted, respectively]. GL: Means of Q2 to Q5 were NS different from Q1 [OR (95% CI), P=0.1234 and P=0.1147, for unadjusted and adjusted, respectively].

		Multivariate logistic regression was used to determine risk of T2D by quintile of energy adjusted dietary GI and GL.	
Schulz M, Liese AD et al, 2006 Study Design: Prospective Cohort Study Class: B Rating:	N=1,600 IRAS subjects. Subjects recruited at four clinical centers from 1992 to 1994. 892 subjects free from T2D at baseline. Equal across gender, age (40 to 49, 50 to 59, 60 to 69 years), ethnicity and glucose tolerance (norm, IGT and T2D). Five-year follow-up.	Multiple logistic regression analysis was used to assess the relationship between GI and GL and T2D risk. Cases further stratified according to abdominal obesity (WC >102cm men; >99cm women) and "change in waist" (↓ = Δ in waist of ≥2cm; stable = ±2cm; ↑ ≥2cm). Adjusted for age, ethnicity, baseline BMI, family history of T2D, smoking, glucose tolerance status, education and energy intake.	At five-year follow-up, subjects diagnosed with T2D according to WHO criteria: 146 cases. Average GI and GL for T2D subjects was 59.5 and 127.9, respectively, NS different from non-T2D subjects, 58.6 and 121.8, respectively. Multivariate regression analysis: GI (β=0.0234, P=0.2); GL (β=-0.0018, P=0.6). Stratification by abdominal obesity at baseline: Positive association between GI and T2D risk among non-abdominally obese subjects [OR first to third tertile=1.90 (95% CI: 0.89, 4.00)]. No association in subjects with abdominal obesity. Stratification by five-year waist Δ: Positive association between GI and T2D risk in subjects with ↑ in WC [OR first to third tertile=1.70 (95% CI: 0.84, 3.47)]. Association was strongest in subjects without abdominal obesity: A one-unit ↑ in GI ↑ T2D risk by 12% [OR 1.12 (95% CI: 1.03, 1.21)] in subjects with waist ↑ without abdominal obesity. NS association between GL and T2D with stratification

			by either abdominal obesity or waist Δ.
Schulze MB, Liu S et al, 2004 Study Design: Prospective Cohort Study Class: B Rating:	N=116,671 women from Nurses' Health Study II. N=91,249, after exclusion. Age: 24 to 44 years at baseline.	Examined association of GI, GL and dietary fiber on T2D risk in young women. In 1991, 91,249 women completed a semi-quantitative FFQ and followed for eight years. The Cox proportional hazards analysis method, stratified by five-year age categories, used for RR for each category of intake (quintiles).	During 716,300 person-years follow-up, 741 T2D cases were diagnosed. ↑ GI strongly associated with progressively ↑ risk of T2D; RR=1.79 (95% CI: 1.43, 2.25). Association remained ↑ after adjustments for BMI, alcohol, smoking, family T2D history and other covariates including dietary and fat intakes. GL and total CHO were inversely correlated with T2D risk; however, association disappeared after adjustment for BMI and other covariates. Significant inverse association between total dietary fiber and T2D risk; RR=0.53 (95% CI: 0.42, 0.67), with cereal fiber having the strongest association, RR= 0.32 (95% CI: 0.25, 0.45). Data further stratified for associations modified by BMI, physical activity and family T2D history: No major Δs were observed for BMI. For physical activity, women in the lower two quintiles of activity had RRs of 2.01 for GI (95% CI: 1.38, 2.93) and 1.65 for GL (95% CI: 1.01, 2.70).

			Among women with no family history of T2D, RR=1.02 for GL and T2D (95% CI: 0.64, 1.63), but women with family history of T2D, RR = 2.04 (95% CI: 1.13, 3.66).
Stevens J, Ahn K et al 2002 Study Design: Prospective cohort Class: B Rating:	N=12,251 adults (9,529 white; 2,722 African American). Atherosclerosis Risk in Communities (ARIC) study. Age: 45 to 64 years at baseline. Location: United States.	Initiated in 1987 to 1989 and included a maximum of four clinical exams that took place at ~three-year intervals. Diet assessed by interviewer-administered FFQ. Diabetes status determined by FBG, non-fasting glucose level, self-report or use of diabetes medication.	During nine years of follow-up, 1,447 cases of diabetes were reported. After adjustment for age, BMI, education, smoking status, physical activity, sex and field center; there was NS association of glycemic index or glycemic load with incident diabetes. The HR for extreme quintiles of GL was 1.10 (95% CI: 0.90, 1.39) in white adults and 0.97 (95% CI: 0.73, 1.35) in African American adults in the fully adjusted model.
Villegas R, Liu S et al, 2007 Study Design: Prospective Cohort Study Class: B Rating:	N=64,227 middle-aged Chinese women with no history of diabetes.	Duration: Five years. FFQ used for in-person interviews conducted on dietary intake and physical activity, conducted at baseline and at the first follow-up. Associations between total CHO intake, GI, GL and specific food groups and T2D incidence were evaluated using multivariable Cox proportional hazards model.	High CHO intake and rice consumption were positively associated with T2D risk. The RR comparing the highest to lowest quintiles was 1.28 (95% CI: 1.09, 1.50) and 1.78 (95% CI: 1.48, 2.15) for CHO and rice consumption, respectively. GI and GL were also positively associated with ↑ risk of T2D; RR=1.21 (95% CI: 1.03, 1.43) and RR=1.34 (95% CI: 1.13, 1.58) for GI and GL, respectively.

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Barclay AW, Flood VM, Rochtchina E, Mitchell P, Brand-Miller JC. Glycemic index, dietary fiber, and risk of type 2 diabetes in a cohort of older Australians. *Diabetes Care.* 2007 Nov; 30(11): 2,811-2,813.

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Stevens J, Ahn K, Juhaeri, Houston D, Steffan L, Couper D. Dietary fiber intake and glycemic index and incidence of diabetes in African-American and white adults: the ARIC study. *Diabetes Care.* 2002;25(10):1715-21.

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